April 5, 1938. G. CAMILLI ET AL 2,113,421

CASCADE TRANSFORMER

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Fig. 1.

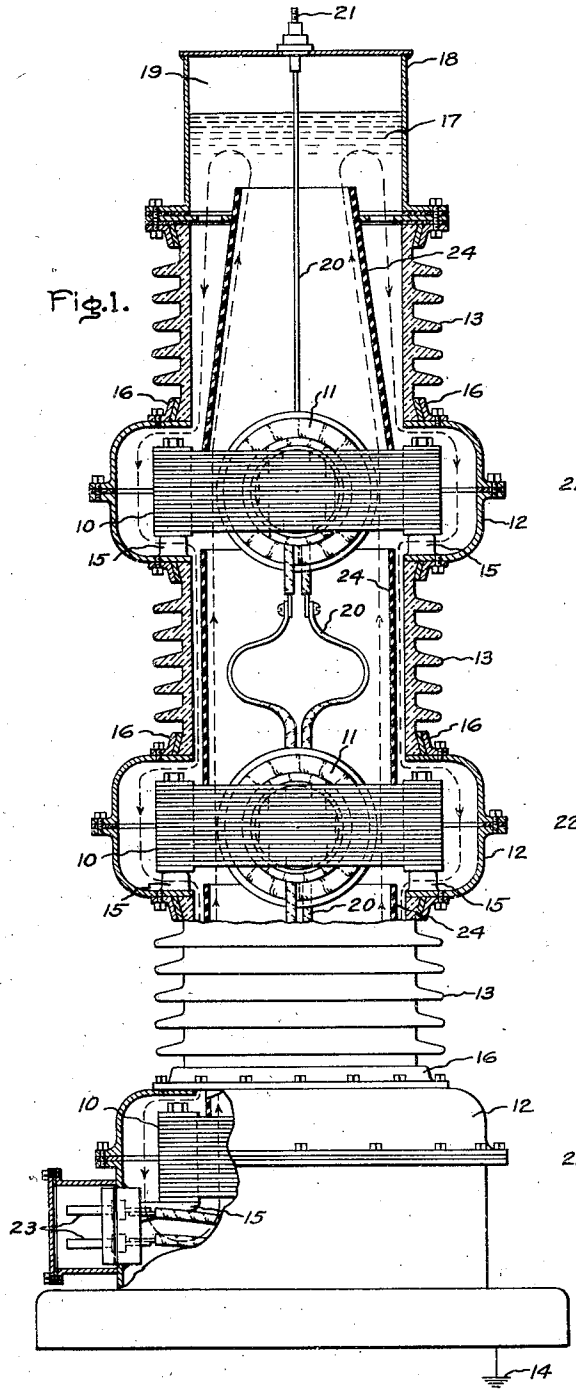
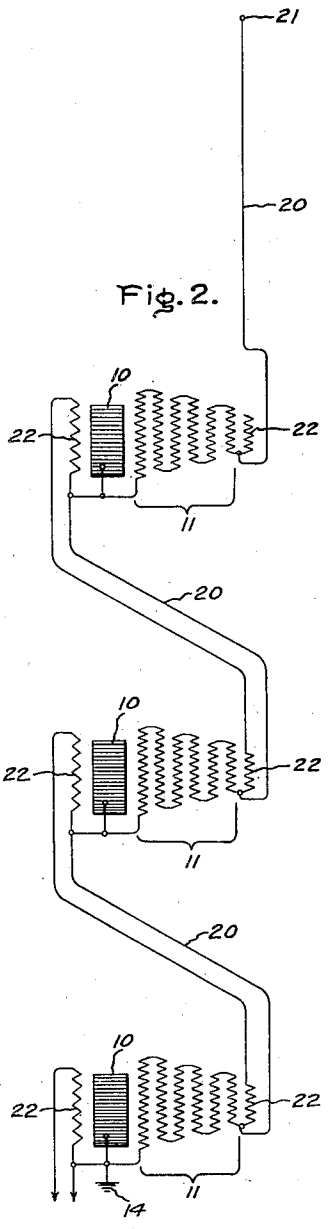


Fig. 2.



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CASCADE TRANSFORMER

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2 Claims. (Cl. 175—361)

Our invention relates to cascade transformers. A transformer of the usual construction with one or both of its windings arranged for operation at very high voltages is necessarily large and expensive because of the large amount of insulation which is required. If the power to be transmitted is rather small, it has been found more economical in many cases to use two or more much smaller transformer units connected in series or cascade.

The general object of the invention is to provide an improved transformer of the cascade type.

Further objects and advantages will appear from the following description taken in connection with the accompanying drawing in which Fig. 1 is a view in elevation, partly in section, of a cascade transformer constructed in accordance with the invention, and Fig. 2 is a diagrammatic view of the transformer connections.

Like reference characters indicate similar parts in both figures of the drawing.

The cascade transformer shown in the drawing includes three transformer units, each having a magnetic core 10 and a high voltage winding 11. The transformer units are enclosed in a vertical casing formed of alternate metallic sections 12 and insulating sections 13. The lowermost casing section 12 encloses the lowermost transformer unit and is preferably connected to a ground 14. Each of the other transformer units is supported in a metallic casing section 12 by spaced supports 15. The metallic casing sections 12 and insulating casing sections 13 are secured together by clamping rings 16 to form a single tubular vertical wall with liquid-tight joints. The casing is filled with an insulating liquid 17 which extends into a metallic cap 18 secured above the uppermost insulating casing section 13, a gas space 19 being left above the level of the liquid in the cap to permit expansion and contraction of the liquid due to changes in temperature. The high voltage windings 11 of the transformer units are connected in series or cascade by conductors 20 between a high voltage terminal 21 and the ground 14, the high voltage terminal 21 being secured to the cap 18. Adjacent transformer units are coupled together by a coupling circuit including a coupling winding 22 on each core, as indicated in Fig. 2, to maintain the uniform distribution of the voltage between the transformer units during normal operation. The use of only one of the coupling windings is necessary of course in the upper transformer unit and in the lower transformer unit. The other winding 22 of the lower transformer unit is connected to terminals 23 and acts as a secondary winding to supply current to a local low voltage circuit.

The magnetic cores 10 of the transformer units are disposed horizontally in their respective casing sections 12 so that the insulating liquid 17 may rise by convection through the openings in the cores as the cores and windings are heated during operation. After rising into the expansion cap 18, the liquid descends along the inner surface of the casing where it is cooled so that after reaching the lower or base section 12 of the casing, it is ready to rise again through the transformer units and absorb more heat. An insulating cylinder or baffle 24 extends above each transformer unit and is spaced from the wall of the casing to separate the current of liquid flowing upwardly through the transformer units and the current of liquid flowing downwardly close to the casing wall, the upward and downward paths of the liquid being indicated by broken lines in Fig. 1. The provision of these baffles increases the velocity of flow of the liquid and consequently the rate at which heat is absorbed from the transformer units and dissipated through the casing wall. The insulating sections 13 of the casing need be only long enough to provide necessary insulation between the transformer units and between the upper transformer unit and the expansion cap 18. They need be only large enough in cross section to provide necessary mechanical strength and to enclose the connections between the transformer units and between the upper transformer unit and the terminal 21 and to conduct the upwardly and downwardly flowing liquid without undue restriction. The inner diameters of the insulating casing sections 13 may therefore be substantially smaller than the outer diameters of the transformer units as indicated in Fig. 1. The metallic casing sections 12, however, are of considerably greater diameter so that they may be spaced sufficiently from the transformer units to permit the descending current of liquid to flow freely. A particularly advantageous feature of the invention is the disposition of the insulating casing sections 13 between the transformer units where these casing sections may be of substantially smaller diameter than that of the transformer units. The insulating casing sections 13 are preferably formed of porcelain which is very expensive and the size of these insulating sections is therefore very important. The metallic casing sections 12 are in intimate contact with

the descending current of insulating liquid 17 and they have excellent heat-conductive characteristics so that they act effectively in cooling the liquid.

The magnetic cores 10 are connected to the high voltage transformer circuit, as indicated in Fig. 2, and the metallic casing sections 12 are electrically connected to their respective magnetic cores 10 through the supports 15 so that each magnetic core and its enclosing metallic casing section assume the potential of the corresponding part of the high voltage circuit. When an abnormally high voltage surge, such as may be caused by lightning or switching operations and which is of extremely brief duration, is impressed on the high voltage terminal 21, a concentration of voltage tends to appear in a small part of the high voltage circuit nearest the high voltage terminal. It is well known, however, that the initial distribution of a sudden surge voltage may be made more uniform throughout the high voltage circuit by increasing the series capacitance between the two ends of the circuit. The presence of the metallic casing sections 12 extended substantially beyond the transformer units which they enclose and connected electrically to adjacent parts of the high voltage circuit obviously increases the series capacitance between the high voltage terminal 21 and the ground 14 and therefore has the effect of substantially increasing the uniformity of distribution of a suddenly impressed high voltage surge on the terminal 21.

The invention has been explained by describing and illustrating a particular construction of cascade transformer including three transformer units but it will be apparent that changes in the number of units and in other features of the construction described may be made without departing from the spirit of the invention and the scope of the appended claims.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. A cascade transformer including two series connected transformer units, a casing enclosing said units, and an insulating liquid in said casing, said casing including a metallic section enclosing each unit and an insulating section between said metallic sections, the inner diameter of the insulating section being smaller than the outer diameter of the transformer units, said transformer units having openings to permit upward flow of said liquid through the units, each metallic casing section being spaced from the transformer unit which it encloses to provide a path for downward flow of the liquid between the transformer units and casing and in contact with said metallic casing sections and said metallic sections being also in contact with the air surrounding the casing to provide effective heat dissipation from the liquid in contact with their inner surfaces.

2. A cascade transformer including two series connected transformer units, and a casing enclosing said units, said casing including a metallic section enclosing each transformer unit and electrically connected to the series transformer circuit, and an insulating casing section between said metallic sections and holding the metallic sections in spaced relation, the inner diameter of the insulating section being smaller than the outer diameters of the transformer units, each metallic casing section being spaced from the transformer unit which it encloses to provide a path for downward flow of the liquid between the transformer units and casing and in contact with said metallic casing sections, and each metallic casing section being also in contact with the air surrounding the casing to provide effective heat dissipation from the liquid in contact with their inner surfaces.

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